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Citation for published version:

Massimi, M 2015, 'Working in a new world': Kuhn, Constructivism and Mind-Dependence', *Studies In History and Philosophy of Science Part A*, vol. 50, pp. 83-89. <https://doi.org/10.1016/j.shpsa.2014.09.011>

Digital Object Identifier (DOI):

[10.1016/j.shpsa.2014.09.011](https://doi.org/10.1016/j.shpsa.2014.09.011)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Studies In History and Philosophy of Science Part A

Publisher Rights Statement:

© Massimi, M. (2014). 'Working in a new world': Kuhn, Constructivism and Mind-Dependence. *Studies in History and Philosophy of Science Part A*. 10.1016/j.shpsa.2014.09.011

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‘Working in a new world’: Kuhn, constructivism, and mind-dependence

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Abstract

In *The Structure of Scientific Revolutions*, Kuhn famously advanced the claim that scientists work in a different world after a scientific revolution. Kuhn’s view has been at the center of a philosophical literature that has tried to make sense of his bold claim, by listing Kuhn’s view in good company with other seemingly constructivist proposals. The purpose of this paper is to take some steps towards clarifying what sort of constructivism (if any) is in fact at stake in Kuhn’s view. To this end, I distinguish between two main (albeit not exclusive) notions of ‘mind-dependence’: a semantic notion and an ontological one. I point out that Kuhn’s view should be understood as subscribing to a form of semantic ‘mind-dependence’, and conclude that semantic ‘mind-dependence’ does not land us into any worrisome ontological ‘mind-dependence’, pace any constructivist reading of Kuhn.

Key words: Kuhn, incommensurability, paradigm shift, constructivism, mind-dependence

1. Introduction

Thomas Kuhn’s *The Structure of Scientific Revolutions*¹ has without any doubt marked a turning point in the way history and philosophy of science has been practiced since. Against the irenic picture of scientific growth marshaled by the logical positivists, Lakatos, and Popper, Kuhn put forward a new picture of how science grows and unfolds, which was bound to attract endless controversies in the decades to come. Paradigm-change and incommensurability have become part of the tool-kit in history and philosophy of science, and continue to spark debates. In this paper, I want to focus my attention on one of the most famous and controversial aspects of Kuhn’s view, namely the claim that “though the world does not change with a change of paradigm, the scientist afterward works in a different world”.² By latching onto the work of Nelson Goodman and *Gestalt* psychology, Kuhn argued that scientists never engage in the simple

¹ Kuhn (1962).

² Kuhn 1962; third ed. 1996, p. 121.

activity of interpreting given data. Experimental data cannot provide a hook to mind-independent reality because laboratory manipulations and measurements are paradigm-dependent. Moreover, different paradigms display different conceptual resources that make possible for scientists (before and after a scientific revolution) to see the world differently.

Kuhn contended for example that Aristotelians saw a falling stone as “a change of state rather than a process (...) the relevant measures of motion were therefore total distance covered and total time elapsed, parameters which yield what we should now call not speed but average speed. Similarly, because the stone was impelled by its nature to reach its final resting point, Aristotle saw the relevant distance parameter at any instant during the motion as the distance *to* the final end point rather than as that *from* the origin of motion”.³

Kuhn argued then that it is the conceptual switch from motion as distance *to* a final end point, to motion as distance *from* the origin that “underlies and gives sense to most of his [Galileo] well-known ‘laws of motion’” (ibid.). This conceptual switch was in turn made possible by “the impetus paradigm” and the Scholastic doctrine of the latitude of forms.⁴ According to the impetus theory, a stone gains increasing impetus as it recedes from its starting point, and hence starting point (rather than end point) became the relevant parameter in assessing the motion of falling stones. Similarly, Aristotle’s notion of speed changed over the Medieval period to include both what we now call ‘average speed’ and what became later known as ‘instantaneous speed’. Hence Kuhn’s conclusion:

But when seen through the paradigm of which these conceptions were a part, the falling stone, like the pendulum, exhibited its governing laws almost on inspection. (...) [Galileo] had developed his theorem on this subject together with many of its consequences before he experimented with an inclined plane. That theorem was another one of the network of new regularities accessible to genius in the world determined jointly by nature and by the paradigms upon which Galileo and his contemporaries had been raised. *Living in that world*, Galileo could still, when he chose, explain why Aristotle had seen what he did. Nevertheless, the immediate content of Galileo’s experience with falling stones was not what Aristotle’s had been.⁵

³ Ibid.,

⁴ Ibid., p. 124.

⁵ Ibid., p. 125. Emphasis added.

The other example Kuhn mentioned in relation to the claim of “working in a new world”, is the passage from affinity theory to Dalton’s atomic theory, whereby the gas mixtures were reinterpreted in terms of specific combinations of whole-number ratios of atomic elements. Kuhn claimed that Dalton successfully operated the conceptual switch from mixtures to compounds because as a meteorologist, he thought that the absorption of gases by water remained a mystery that affinity theory could not explain, and as such he was immune from the chemical paradigm of his time.⁶

How should we understand Kuhn’s claim that scientists before and after a revolution ‘work in a different world’? Ian Hacking⁷ has famously argued that the world consists of individuals, and as such it does not change during a scientific revolution. Yet, the world scientists work in and act upon is not a world of individuals but a world of kinds, and kinds typically change during a scientific revolution. More recently, Paul Boghossian has discussed Kuhn’s influence for constructivism, and in particular for a weak form of constructivism about rational explanation, as the view that evidence is never sufficient to underpin our beliefs.⁸

The goal of this paper is to clarify what sort of constructivism (if any) is licensed by Kuhn’s claim. I will go back to Kuhn’s example about Galileo’s falling stone and elucidate the sense in which it can make sense to say—as Kuhn did—that scientists before and after Galileo *saw* the falling stone differently. I will then draw conclusions about the implications of Kuhn’s view for constructivism by ruling out a prominent sense of ‘mind-dependence’, which I think has been mistakenly associated with Kuhn. My goal is to take Kuhn’s claim as a springboard for analyzing two possible ways of understanding the ‘working in a new world’ claim: (1.) an ontological sense; and (2.) a semantic sense, respectively. These two possible readings deliver two distinctive notions of mind-dependence, which—one way or another—seem to be at work in Kuhn’s contentious claim. I argue for three main points (the first historical, and the remaining two more philosophical):

- I. Pace Kuhn, there is a lot of historical continuity between the way Galileo saw the falling stone and the way in which the Aristotelian-Scholastic tradition saw it.

⁶ Ibid. pp. 133-5.

⁷ Hacking (1993), p. 289.

⁸ Boghossian (2006), pp. 118-125. Boghossian concludes that Kuhn’s incommensurability does not open the door to any such weak constructivist thesis, Kuhn’s influence on constructivism notwithstanding.

- II. Kuhn's 'working in a new world' claim is better understood as implying a form of semantic mind-dependence.
- III. Kuhn's semantic mind-dependence does not license ontological mind-dependence, *pace* readings of Kuhn as advocating some form of fact-constructivism.

Before plunging into the philosophical points II. and III., let us go back to Galileo and the falling stone.

2. Galileo and the falling stone

The purpose of this Section is to clarify from a historical point of view three main things: first, how Aristotelians saw the falling stone; second, how Galileo's change in the way in which he could 'see' the falling stone was in continuity with important Medieval studies that built up on Aristotle's view; and third, clarify from a historical point of view what Galileo *saw new* in the falling stone.

First, what did Aristotelians see in the falling stone? Aristotle, just like Galileo after him, saw the falling stone as accelerating, although he was not clear about either the cause of the acceleration or its kinematic features. Aristotle seemed to have believed that bodies tend to accelerate the closer they get to their natural place: for example, falling stones would accelerate nearer to the earth as much as fire would accelerate nearer to the upper region (*qua* fire's natural place). Aristotle explained this acceleration of motion in terms of the body increasing either its weight (falling stone) or its lightness (fire), the nearer it came to its natural place. Medieval commentators of Aristotle, such as Simplicius, interpreted Aristotle's view in terms of the body regaining its 'form' in a more complete way in proximity of its natural place.⁹ But an alternative view (defended by Hipparchus) was also available in Medieval times to explain why bodies moved more swiftly the nearer they were to the earth: acceleration of falling stones could have been due to a decrease in the amount of air underneath, as opposed to an increase in the weight of the stone itself. Heavy bodies would fall more quickly near the Earth because the air underneath them would provide less resistance (vice versa, light objects would be easily buoyed up by the underlying air). A third view, popular with Arabic commentators

⁹ In what follows I draw on M. Clagett (1959), which is the book Kuhn refers to in the passage where the 'working in a new world' claim is put forward in relation to Galileo's falling stone.

of Aristotle, such as Avicenna and Abū'l-Barakāt in turn explained acceleration in terms of two opposing forces: what they called a violent *mail* as a force inherent in the body and driving it towards a place different from its natural one; and a natural *mail* as a force that would instead conduce the body to its natural place. The violent *mail* would slow down the body in its initial descent, while the natural *mail* would increase the speed of the body. This view eventually resulted in the impetus theory of John Buridan in the first half of the fourteenth century, where acceleration was explained by the increase of an intrinsic force called *impetus* due to some form of permanent natural gravity. With Nicole Oresme, impetus was no longer regarded as due to some natural gravity of the body, but to an initial acceleration, increasing along the descent. In this way, the impetus theory provided a uniform framework for the explanation of both free fall and projectile motion.

Coming to the second aforementioned point, there is significant continuity between Galileo's research on free fall and the Aristotelian tradition, filtered through Medieval scholars. Kuhn's 'working in a new world' claim notwithstanding, there are at least three main respects in which Galileo borrows from the previous Aristotelian-Medieval tradition about free fall:

1. *Buoyancy in Galileo's early study on mechanics*: in continuity with the second aforementioned view (defended by Hipparchus), in his early Pisan treatise *De motu antiquiora* (1589-92, the book was never published and it is referred to by Galileo in *Two New Sciences*), Galileo embraced a similar buoyancy to explain accelerated motion in analogy with Archimedes' hydrostatics (by considering the ratio between weight per volume of the body and weight per volume of the surrounding medium, e.g., air). Thus, if bodies seemed sometimes to move upwards, this was not because they moved towards a natural place (as Aristotle claimed) but because they must have had a specific weight that made them 'float' in their surrounding medium.¹⁰ It took Galileo some time to correct the basic mistake of searching for a sort of Archimedean-like relation between velocity change and specific density, rather than searching for velocity change with respect to *time* (which seems to date back to 1609). Moreover, it took him some time to clearly articulate how the gravity of a body (as an internal static

¹⁰ On the Archimedean origins of Galileo's theory of motion, see Machamer (1998); and Westfall (1971), ch. 1.

force) could enter in the explanation of degrees of velocity (*celeritatis momenta*) acquired by bodies in their free fall. On both scores, there are nonetheless important continuities with the earlier tradition.

2. *Latitude of forms and degrees of speed*: a key ingredient in Galileo's later law of free fall, as demonstrated in the 1638 *Two New Sciences*, is the so-called mean speed theorem, which says that the time in which a certain space is traversed by a moveable in uniformly accelerated motion from rest is equal to the time in which the same space would be traversed by the same moveable carried in uniform motion, whose degree of speed is one-half the maximum and final degree of speed of the uniformly accelerated motion.¹¹ The distinctively geometrical reasoning underlying Galileo's analysis of what we might call today 'instantaneous velocity', in the absence of a proper mathematical language such as calculus in which to express such quantity, betrays once more Galileo's debt to the Aristotelian–Medieval tradition. Indeed the mean speed theorem, which gives uniform acceleration in terms of the velocity at the middle instant of the time interval during which acceleration occurs, had been proved by the Merton School, most notably Heytesbury and Swinshead, sometimes around 1330s and 1340s. This geometrical way of thinking about instantaneous velocities in the pre-calculus era was in turn rooted in a influential Medieval view called the 'latitude of forms', where degrees of speed could be geometrically thought of as intensions (or quantities) of an extended quality, whose overall extension was called 'latitude'. For example, according to the latitude of forms, one could represent velocity as a rectilinear line, whose instantaneous velocities could in

¹¹ See Galileo (1638), p. 208. This is because if we imagine a body descending through an inclined plane at time $t_0...t_2$ and acquiring a further degree of velocity at any further instant, and if we now imagine that at t_2 the plane from inclined becomes flat and perfectly horizontal, then we would have that the final and maximum degree of speed acquired in the uniformly accelerated motion at t_2 becomes the degree of speed that the same moveable would now have in its uniform horizontal motion. This means that in the following two seconds $t_2...t_4$, the moveable would travel with uniform velocity on the horizontal plane a distance which is exactly twice the distance it travelled in $t_0...t_2$ with uniformly accelerated motion. So in the same time-intervals Δt , namely $t_0...t_2$ and $t_2...t_4$, the moveable covers twice the distance with uniform velocity. Hence with *half* uniform velocity (which recall is equal to the maximum and final degree of speed of uniformly accelerated motion), it would cover exactly the *same* distance it covered with uniformly accelerated motion on the inclined plane.

turn be represented as perpendicular lines, corresponding to the degrees of speed at each time instant. The view became famous through the Medieval text *De latitudinibus formarum*, probably written by Jacob of San Martino, building up on the work of Nicola Oresme, around 1359.¹² Thus, Galileo's distinctively geometrical way of thinking about the kinematical properties of uniform acceleration betrays once more his allegiance to the Scholastic tradition.

3. *Acceleration proportional to the time of fall*: one of the main obstacles in arriving at the law of free fall was the mistaken idea that the degrees of speed were proportional to the space traversed (the greater the distance, the greater the speed). Galileo himself made this in the famous letter to fra' Paolo Sarpi in 1604 where he first announced his mistaken law of free fall as $v : s$. The first Medieval scholar to hit on the idea of acceleration being proportional to the time of the fall, rather than the distance was Jordanus in a thirteenth century treatise called *De ratione ponderis*.¹³ Of course, Jordanus did not have a law of free fall, or a law that could express instantaneous velocities, but in a way, it shows once more that Galileo's breakthrough of associating first velocity with time, and then space traversed in free fall with the square of the time had been made possible by earlier thinkers.

Coming to my third and final point for this Section, what did Galileo *see new* in the falling stone that his predecessors had not seen? If Kuhn is right that looking through the lenses of the Medieval impetus theory and latitude of forms, Galileo could see for the first time regularities nowhere clearly displayed in nature, one should ask what did he see that Buridan, Oresme, and the Merton School could not have possibly seen?

There seems to be two key moments in Galileo's discovery of the law of free fall. First, the realization, following up on a similar one by Jordanus, that in uniform acceleration velocity is proportional to time and not to space. In *Two New Sciences* Galileo clearly defined uniformly accelerated motion as the motion that "starting from rest, it acquires, during equal time-intervals, equal increments of speed [temporibus aequalibus aequalia celeritatis momenta sibi superaddit]".¹⁴ Second, the use of an important supposition in the mathematical demonstration of the $s : t^2$ theorem, namely that the

¹² For a discussion of this text, its author and possible date of publication see Clagett (1959), p. 395.

¹³ Ibid., p. 548.

¹⁴ Galileo (1638), p. 169.

“speeds acquired by one and the same body moving down planes of different inclinations are equal when the heights of these planes are equal”.¹⁵ This supposition entered in the way Galileo *saw* the inclined plane experiments to support $s : t^2$ as a general law valid also for the case where the inclination of the plane vanishes to zero, to become free fall along the vertical line. I have reconstructed elsewhere the thought experiment with arcs and chords used by Galileo to validate the allegedly indubitable status of this supposition.¹⁶ In that paper, I concluded that what is revolutionary about the way Galileo *saw* the falling stone is the specific way in which Galileo constituted the spatio-temporal properties of appearances such as balls rolling down inclined planes (i.e. via the supposition of equal degrees of speed over different inclined planes with the same height) and then subsumed them under a causal concept (i.e. a weight-related force concept such as impeto that entered into the quasi-demonstration of the supposition).

Where does all this leave us regarding Kuhn’s claim that scientists work in a new world, after Galileo? Should we conclude that the phenomenon of uniformly accelerated motion was fabricated / constructed by Galileo? What sort of mind-dependence is at stake here? In the next Section I address this philosophical question by first distinguishing between two possible notions of mind-dependence.

3. Two notions of mind-dependence

In what follows, I want to take some preliminary steps towards distinguishing two main notions of mind-dependence, which seem to be intertwined in Kuhn’s ‘working in a new world’ claim. These two notions are by no means the only two possible ones (for a third epistemic notion of mind-dependence may also be lurking in the background), but for the purpose of this paper, I am going to confine my attention to these two varieties only.¹⁷

- 1) (Ontological notion): mind-dependence₁ as belief-dependence. Under this first notion of mind-dependence, a scientific kind k is dependent upon the *belief* that a person S forms about k . This version of mind-dependence implies an ontic claim

¹⁵ Ibid., p. 169.

¹⁶ See Massimi (2010).

¹⁷ I have analyzed an epistemic notion of mind-dependence, which I take to represent a somehow Kantian view of how reality is affected by our conceptual resources within the context of a discussion about natural kinds, in Massimi (2012).

about what there is being dependent on us, our minds, and cognitive faculties. There are two possible strands under this ontic variety: *idealism* and *social constructivism*.

- 1.i. On the idealistic strand, uniformly accelerated motion is instantiated in nature to the extent to which Galileo as a scientist formed particular *beliefs* about rolling stones so as to make immediately visible a regularity otherwise nowhere clearly exemplified in nature.
 - 1.ii. Under the *social constructivist* strand, mind-dependence₁ becomes a form of society-dependence. On this account, one could make the claim that uniformly accelerated motion was socially constructed as a new kind of motion by Galileo and his followers, including Newton, via their laboratory life (to echo Latour), and that before Galileo, there is no sense to the idea that falling stones had uniformly accelerated motion.
- 2.) (Semantic notion): mind-dependence₂ as description-dependence. On this view, a scientific kind *k* is dependent upon a particular description given by a particular language *L*. Under this semantic view, one can include both Hanson's view¹⁸ and Kuhn's view, both in *The Structure of Scientific Revolutions* and even more so in the late 1980s essays. Hanson's and Kuhn's views are similar and are often discussed together in the literature,¹⁹ but I want to distinguish between them here.
2. i. Hanson claims that facts are "somehow moulded by the logical forms of the fact-stating language", ²⁰ namely that "the formation of a concept *x* in a language not rich enough to express *x* (or in a language which explicitly rules out the expression of *x*), is always very difficult". Hanson gives the example of Galileo, who in 1638 in *Two New Sciences* introduced the concept of constant acceleration for free falling bodies without having a proper language (in the pre-calculus era) to express this concept because the geometrical notation, dominant at the time, led people to think of velocities as proportional to spaces traversed as opposed

¹⁸ See Hanson (1958).

¹⁹ Boghossian (2006), pp. 118-125, discusses the extent to which Kuhn's arguments can be used to support constructivist theses. I have distinguished between Hanson's and Kuhn's view in Massimi (2012), pp. 18-19.

²⁰ Hanson (1958), ed. used (1972), p. 36.

to times. It was only with the introduction of Newton's fluxions that it became possible to symbolise constant acceleration as \dot{v} .

2.ii. With Kuhn, mind-dependence₂ becomes a form of paradigm-dependence, or scientific-lexicon-dependence, whereby a scientific kind k is dependent upon the scientific paradigm, or the scientific lexicon (to use Kuhn's later terminology) endorsed by a given community at a given time. Hence, incommensurability (in its semantic form, most evident in Kuhn's late 1970s and early 1980s essays) becomes a form of untranslatability between scientific lexicons. Already in *The Structure of Scientific Revolutions*, Kuhn suggests such a semantic reading in relation to the 'working in a new world' claim. Indeed, to clarify how Aristotelians could not have possibly seen the falling stone as Galileo did, Kuhn deploys some resources that became central to his later analysis of scientific lexicons, namely the idea that language acquisition is a holistic process: "neither scientists nor laymen learn to see the world piecemeal or item by item...The child who transfers the word 'mama' from all humans to all females and then to his mother is not just learning what 'mama' means or who his mother is. Simultaneously, he is learning some of the differences between males and females as well as something about the ways in which all but one female will behave toward him. (...) By the same token, the Copernicans who denied its traditional title 'planet' to the sun were not only learning what 'planet' meant or what the sun was. Instead they were changing the meaning of 'planet' so that it could continue to make useful distinctions in a world where all celestial bodies, not just the sun, were seen differently from the way they had been seen before".²¹

In the rest of this paper I want to substantiate two main points. First, that Kuhn's view falls squarely within a semantic account of mind-dependence; and, second, that semantic mind-dependence does not entail ontic mind-dependence, pace any constructivist reading of Kuhn.

4. Incommensurability as untranslatability between scientific lexicons

²¹ Kuhn (1962), pp. 128-9.

Kuhn's view falls squarely within the semantic notion of mind-dependence₂: while the semantic reading is already evident in *The Structure of Scientific Revolutions*, it becomes prominent in the late Kuhn where the notion of incommensurability got redefined as a form of untranslatability between scientific lexicons. Applied to the conceptual vocabulary of a scientific theory, the term 'incommensurability' came to mean 'no common measure' intended as 'no common language'. Incommensurability amounted to the claim that there is no language into which both theories, conceived as sets of sentences, can be translated without residue or loss.²² Untranslatable lexicons still imply that scientists before and after a revolution work in a new world.

Kuhn defined a scientific lexicon as the conceptual vocabulary of a scientific theory, consisting of 'kind terms', subject to what Kuhn calls the *no-overlap principle*:

no two kind terms, no two terms with the kind label, may overlap in their referents unless they are related as species to genus. There are no dogs that are also cats, no gold rings that are also silver rings, and so on: that's what makes dogs, cats, silver, and gold each a kind.²³

Kuhn associated kind terms with nomic and normic generalizations, where the former are laws of nature, the latter are generalizations amenable to exceptions. The same no-overlap principle that bars practitioners of a lexicon from importing kind terms into another lexicon, bars them also from importing some of the laws associated with kind terms into a new lexicon.²⁴ Indeed, in Kuhn's view, the main terms of any scientific theory are acquired together with the main laws of the theory. In Newtonian mechanics, the terms 'force', 'mass', and 'acceleration' are interdefined and acquired together with Newton's second law as a law-sketch that must be rewritten in different symbolic forms depending on the specific problems it is applied to (from the free fall, to the pendulum, to coupled harmonic oscillators). Physics students learn that in the Newtonian lexicon free fall is an example of 'forced' motion (instead of 'force-free' motion as it was for Aristotelians). As such, it is subject to a suitable symbolic expression of Newton's second law. These are the nomic expectations that the term 'free fall' brings along with it as a projectible term, and that make the term not translatable into the language of any physical theory where Newton's version of the second law does not apply. Thus, as Kuhn repeatedly stressed,

²² Kuhn (1983). Reprinted in Kuhn (2000), p. 36.

²³ Kuhn (1991). Reprinted in Kuhn (2000), p. 92.

²⁴ *Ibid.*, p. 336.

acquiring a new scientific lexicon is equivalent to learning a new language: it requires bilingualism, not translatability.

There are two main assumptions underpinning the untranslatability thesis. The first is the identification of lexical structures with lexical taxonomies.²⁵ So, for example, the Aristotelian statement ‘free fall is accelerated motion’ cannot be translated into the Galilean lexicon, because although the term ‘free fall’ appears as a kind term in both lexicons, the two overlap without the sentence being translatable, because a major conceptual change has in the meantime occurred (e.g., from free fall as a force-free accelerated motion towards a natural place within the Aristotelian lexicon, to forced motion within the Galilean lexicon). A second important assumption is that taxonomy must be preserved for translation to be possible.²⁶ But the no-overlap principle makes taxonomy-preservation impossible, by barring overlapping between taxonomic categories belonging to the same contrast set (while allowing inclusive overlapping of genus–species type). We should then focus on this taxonomic requirement to establish whether ontic mind-dependence₁ may follow from Kuhn’s semantic mind-dependence₂.²⁷

5. Why Kuhn’s semantic mind-dependence₂ does not license ontic mind-dependence₁

How should we understand the claim that lexical structures are taxonomic? From a semantic point of view, the taxonomy requirement imposed by the no-overlap principle seems to amount to the following claim:

²⁵ See on this point Kuhn (2000), pp. 92–3. I have discussed these two assumptions in more details in Massimi (2005), ch. 3, on which I draw here.

²⁶ “The lexical structures employed by speakers of the languages must be the same, not only within each language but also from one language to the other. *Taxonomy must, in short, be preserved to provide both shared categories and shared relationships between them.* Where it is not, translation is impossible”. Kuhn (1983). Reprinted in Kuhn (2000), p. 53. Emphasis added.

²⁷ In what follows, I am not going to make a distinction between the idealistic and the social constructivist strands under mind-dependence₁, but I simply take mind-dependence₁ as an ontic view about what there is being dependent on us (individuals or society) to exist (e.g. for example, social constructivists would insist that nature is not just mind-dependent but dependent on our current scientific practice).

(A.) If t_1 is a kind term in a scientific lexicon L_1 , then t_1 cannot be a kind term in another lexicon L_2 , unless it becomes a sub-kind-term t_1^* of a new kind term t_2 in L_2 .

In the Galileo case, the kind term ‘free fall’ in the Aristotelian-Medieval lexicon L_1 cannot be imported in Galileo’s lexicon L_2 unless it were related to Galileo’s ‘free fall’ as an inclusive species-to-genus overlapping. For the taxonomic, species-to-genus relation to hold between any two kind terms of two different lexicons, the following condition has to hold in turn:

(A.i.) A kind term t_1 of a lexicon L_1 can become a sub-kind-term t_1^* of a new kind term t_2 in L_2 if and only if the kind k_1 captured by t_1 can become a proper sub-kind k_1^* of the new kind k_2 captured by t_2 in L_2 .

In the above definition, by ‘kind’ k I mean the semantic kind picked out by the relevant kind terms, or if you like, the <kind concept> associated with the relevant kind terms—I do not mean ‘kind’ in a metaphysical sense of natural kinds carving nature at its joints. Whenever the old taxonomic kind k_1 captured by t_1 (say, Aristotle’s <free fall>) cannot become a sub-kind of a new kind k_2 captured by t_2 (say, Galileo’s <free fall>), because a fundamental change has occurred in this taxonomic category in the meantime (from force-free to forced motion, for example), then the two terms are untranslatable, according to Kuhn’s no-overlap principle. This change in the taxonomic category results, in turn, into a change in the classes of objects picked out by the kind term ‘free fall’ in the Aristotelian and Galilean lexicon, respectively (say, the upward motion of fire was classified as a force-free accelerated motion as much as the downward motion of stones in the Aristotelian lexicon, but not in the Galilean one). So the two classes of objects become non-overlapping.

What theory of reference is at work in Kuhn’s semantic mind-dependence₂? Kuhn never endorsed Putnam–Kripke causal theory of reference, as he made it clear in his response to Hacking precisely on this topic.²⁸ Kuhn argued that in the case of

²⁸ This is what Kuhn has to say about theories of reference in his reply to Hacking’s (1993) paper, published at the end of Horwich’s volume: “Though the solution he [Hacking] describes was never quite my own and though my own has developed substantially since the manuscript he cites was written, I take immense pleasure in his paper. (...) His nominalist version of my position — there are really individuals out there, and we divide them into kinds at will — does not quite face my problems. The reasons are numerous, and I mention only one here: how can the referents of terms like ‘force’ and ‘wave front’ (...)”

polysemous terms such as ‘water’, any attempt to resolve the tension by introducing two terms, ‘water₁’ and ‘water₂’, to designate two different meanings (water before and after isotopes) sharing nonetheless the same referents, ‘is (...) linguistically unsupportable’.²⁹ Epistemically, <water₁> and <water₂> are very different kind concepts, associated with different projectible expectations.

Kuhn then seemed to suggest that any attempt to bypass the ‘working in a new world’ problem by explaining how the reference of our kind terms is causally fixed (so that despite meaning-change, our kind terms are still referring to the same objects before and after a revolution) is not an option. It presupposes exactly the causal theory of reference dear to Hacking and Putnam alike, but at odds with the whole Kuhnian enterprise of defining kind terms through their corresponding kind concepts and projectible expectations due to nomic generalizations. In what follows, I want to suggest that Kuhn tacitly endorsed a Fregean theory of reference, whereby the reference of kind terms is fixed through the sense, or intension captured by the corresponding <kind concept>. We should then ask how the Fregean theory of reference enters into the ‘working in a new world’ claim, and second, whether it licenses any ontic mind-dependence of constructivist flavour.

How does the Fregean account enter into the ‘working in a new world’ claim? I think there is a distinctive way in which Kuhn is tacitly using a Fregean hidden lemma to conclude that scientists after a revolution work in a different world. The Fregean hidden lemma enters in the way in which, given the no-overlap principle, Kuhn concludes the following:

(X.) For any kind k_i and non-overlapping classes of objects C_i and C_i^* , if k_i picks out C_i then some other kind k_i^* must pick out C_i^* .

be construed as individuals? I need a notion of ‘kinds’, including social kinds that will populate the world as well as divide up a pre-existing population. That need in turn introduces a last significant difference between me and Ian. He hopes to eliminate all residues of a theory of meaning from my position; I do not believe that that can be done. (...) Both ‘water₁’ and ‘water₂’ [before and after isotopes, MM] are kind terms: the expectations they embody are therefore projectible. Some of those expectations are different, however, which results in difficulties in the region where they both apply”. Kuhn (1993), pp. 315–9. In other words, for Kuhn it is not the case that a natural kind term such as ‘water’ refers to the same stuff named in an original causal baptism, irrespective of the conceptual changes that the term may have undergone to in the meantime.

²⁹ Ibid., p. 318.

In other words, (X.) captures Kuhn's conclusion that given any two non-overlapping (i.e. non species-to-genus) classes of objects,³⁰ there must be two distinct (non-overlapping) kind concepts picking them out. The distinct, non-overlapping kind concepts are the result of scientific revolution and paradigm shifts. Ultimately, we work in different worlds because our kind concepts have changed during a scientific revolution. The argument from the no-overlap principle defined as in (A.) above to the conclusion (X.), runs as follows:

(A.) If t_1 is a kind term in a scientific lexicon L_1 , then t_1 cannot be a kind term in another lexicon L_2 , unless it becomes a sub-kind-term t_1^* of a new kind term t_2 in L_2 .

(A.i.) A kind term t_1 of a lexicon L_1 can become a sub-kind-term t_1^* of a new kind term t_2 in L_2 if and only if the kind k_1 captured by t_1 can become a proper sub-kind k_1^* of the new kind k_2 captured by t_2 in L_2 .

(2.) A kind k_1 captured by t_1 can become a proper sub-kind k_1^* of a new kind k_2 captured by t_2 in L_2 if the taxonomic changes associated with different nomic expectations result in k_1 still picking out the same class of objects, now called C_1^* as a proper subset of a larger overlapping class of objects C_2 captured by k_2 (I take this to be the Fregean hidden lemma: different intensions associated with t_1 before and after a revolution may still track the same class of objects, provided that an inclusive species-to-genus overlapping of the old extension with the new extension is in place)

(3.) Let C_1 and C_1^* be the classes of objects picked out by k_1 and k_1^* , before and after a revolution respectively; and let C_1 and C_1^* be non-overlapping (i.e. they do not encompass exactly the same objects and no inclusive species-to-genus overlapping is in place).

(4.) By (A.i.), (2.) and (3.), it follows that the kind k_1 is not a sub-kind k_1^* of a new kind k_2 in L_2

(5.) By (A.), (A.i.) and (4.), it follows that the term t_1 is not a sub-kind-term t_1^* in L_2 .

³⁰ Think of the class of objects captured by the kind term 'planet' before and after Copernicus; or, the class of objects captured by the kind term 'free fall' before and after Galileo as soon as free fall ceased to be regarded as a force-free motion and became an instantiation of Newton's second law.

(X.) For any kind k_i and non-overlapping classes of objects C_i and C_i^* , if k_i picks out C_i then *some other kind* k_i^* (i.e., not a sub-kind of k_i) must pick out C_i^* .

During a scientific revolution, the old kind concepts and the nomic generalizations associated with kind terms change, ensuing into non-overlapping (i.e. non species-to-genus) classes of objects. I want to draw attention to the peculiar way in which Kuhn seemed to be using the Fregean hidden lemma (2.) in reaching conclusion (X.). I contend that Kuhn is making a non-orthodox use of the Fregean lemma, via his taxonomic requirement expressed by the no-overlap principle in (A.).

First, to the kosher Fregean eye, it is not necessary that different intensions denote different classes of objects. After all, Frege's distinction between *Sinn und Bedeutung* was functional to defend the opposite point, namely that different intensions can still denote the same object. Thus, no change to our <kind concept> k_i and nomic generalizations attached to it *per se* implies that our old kind term t_i cannot track the same reference, before and after a revolution. For Kuhn's 'working in a new world' claim (X.) as a semantic thesis to follow from the Fregean hidden lemma (2.), Kuhn had to introduce the additional taxonomic requirement that an inclusive species-to-genus relation has to hold between the old extension and the new extension of the kind term at issue. This taxonomic requirement is captured by the no-overlap principle, i.e. premise (A.) in the argument above, and, I contend, this is an extra assumption, which *per se* has nothing to do with the Fregean view that Kuhn seemed to be subscribing to.

Second, we should ask whether the Fregean view at work in Kuhn's 'working in a new world' claim (X.) licenses any ontic mind-dependence of constructivist flavour. Namely, whether it is possible to derive from Kuhn's semantic conclusion (X.) the constructivist conclusion that scientists before and after a revolution literally work in a different world, populated by different natural kinds. I think the answer is negative. All that (X.) shows, as a semantic thesis, is that if C_i and C_i^* are non-overlapping classes of objects, and k_i picks out C_i , then k_i must be different from k_i^* (i.e. k_i^* cannot be a sub-kind of k_i). In other words, given the no-overlap principle (premise A.) and given non-overlapping classes of objects (premise 3.), assuming a Fregean view of how kind terms fix their reference, Kuhn seems to conclude that different <kind concepts> k_i and k_i^* must pick out non-overlapping classes of objects.

Does this claim amount to a form of fact-constructivism? I think the answer is no. After all, recall that k_i and k_i^* featuring in premise (A.i) of the above argument are

semantic kinds, not metaphysical kinds; they can be thought of as <kind concepts> playing the role of Fregean intensions in explaining how the reference of kind terms gets fixed. They are more precisely kind descriptions through which our terms t_i and t_i^* get hooked up to their referents. To take the semantic conclusion (X.) as implying a form of ontic mind-dependence₁ is tantamount to reifying Fregean intensions into metaphysical kinds. I admit that Kuhn's ambiguous language on the matter may leave enough leeway to speculate here, and it is precisely Kuhn's ambiguity on the matter that left wide open the issue of what Kuhn meant exactly by 'working in a new world'. But only through a constructivist sleight of hand on Kuhn's behalf, can <kind concepts> k_i get reified into ontological kinds. After all, that k_i and k_i^* are *ontologically* different kinds (and not just different <kind concepts>, or Fregean intensions) is precisely what we need to show for ontic mind-dependence₁ to follow from semantic mind-dependence₂. Thus, claiming that different kinds pick out different non-overlapping classes of objects, as per (X.), does not begin to show that we *literally* 'work in a new world' before and after a revolution, pace attempts to read Kuhn along fact-constructivist lines.

6. Conclusion

To conclude, in this paper I have endeavoured to show three main points. First, pace Kuhn the philosopher, even a cursory look at the history of the free fall shows that what made it possible for Galileo to see the falling stone as uniformly accelerated was precisely an influential Medieval tradition of mechanical studies, ranging from Oresme's latitude of forms to the Merton School introduction of the mean speed theorem. Hence, there is significant historical continuity between the way in which the Aristotelian–Medieval tradition saw the falling stone and the way in which Galileo saw it.

Second, that Kuhn's view (both in *Structure* and even more so in later writings) is better understood as subscribing to a form of semantic mind-dependence, captured by the no-overlap principle and its role for the untranslatability of scientific lexicons. And finally, that semantic mind-dependence does not open the door to any controversial ontic mind-dependence, pace any temptation to read Kuhn along constructivist lines.

Acknowledgements

Earlier versions of this paper were presented at the Integrated HPS conference in Athens and the Boston Colloquium for the Philosophy of Science, on the occasion of the 50th

anniversary of Kuhn's *Structure of Scientific Revolutions* (March 2012). For comments and feedback on these earlier versions, I am grateful to Alexander Bird, Alisa Bokulich, Don Howard, Paul Hoyningen-Huene, Vasso Kindi, John Norton, Stathis Psillos, John Stachel, Tom Ryckman, and Brad Wray. Special thanks to Theodore Arabatzis for very helpful editorial comments on an earlier draft of this paper.

Bibliography

- Boghossian, P. (2006) *Fear of Knowledge. Against relativism and constructivism* (Oxford: OUP).
- Clagett, M. (1959) *The Science of Mechanics in the Middle Ages* (Madison: University of Wisconsin Press).
- Galileo G. (1638) *Discorsi e dimostrazioni matematiche intorno a due nuove scienze*, in (1890–1909) *Opere di Galileo Galilei*, vol. VIII (Favaro ed.), Firenze: Barbera. English translation by H. Crew and A. de Salvio *Discourses and Mathematical Demonstrations concerning Two New Sciences* (New York: Dover Publications).
- Hacking, I. (1993) 'Working in a New World: the Taxonomic Solution', in P. Horwich (ed.), 1993, *World Changes. Thomas Kuhn and the Nature of Science*; Cambridge, Mass.: MIT Press, pp. 275–310.
- Hanson, N. R. (1958) *Patterns of Discovery* (New York: Cambridge University Press).
- Kuhn, T. S. (1962) *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press).
- _____(1983) 'Commensurability, comparability, communicability'. In P. D. Asquith and T. Nickles (eds.) *PSA 1982. Proceedings of the 1982 Biennial Meeting of the Philosophy of Science Association*, vol. 2 (East Lansing, MI: Philosophy of Science Association). Reprinted in Kuhn (2000), pp. 33–58.
- _____(1991) 'The road since Structure', in A. Fine, M. Forbes, and L. Wessels (eds.) *PSA 1990 Proceedings of the 1990 Biennial Meeting of the Philosophy of Science Association*, vol. 2 (East Lansing, MI: Philosophy of Science Association). Reprinted in Kuhn (2000), pp. 90–105.
- _____(1993) 'Afterwards', in P. Horwich (ed.) *World Changes. Thomas Kuhn and the Nature of Science* (Cambridge, Mass.: MIT Press), 311–39. Reprinted in Kuhn (2000), 224–53.
- _____(2000) *The Road since Structure. Philosophical Essays, 1970–1993, with an Autobiographical Interview* (Chicago: University of Chicago Press).

- Machamer, P. (1998) 'Galileo's machines, his mathematics, and his experiments', in *The Cambridge Companion to Galileo* (ed. by P. Machamer), Cambridge: Cambridge University Press.
- Massimi, M. (2005) *Pauli's Exclusion Principle. The Origin and Validation of a Scientific Principle* (Cambridge: Cambridge University Press).
- _____(2010) 'Galileo's mathematization of nature at the crossroad between the empiricist and the Kantian tradition', *Perspectives on science* 18, 152–188.
- _____(2012) 'Natural Kinds and naturalized Kantianism', *Noûs* (Early View)
- Westfall, R. (1971) *Force in Newton's Physics* (New York: American Elsevier).